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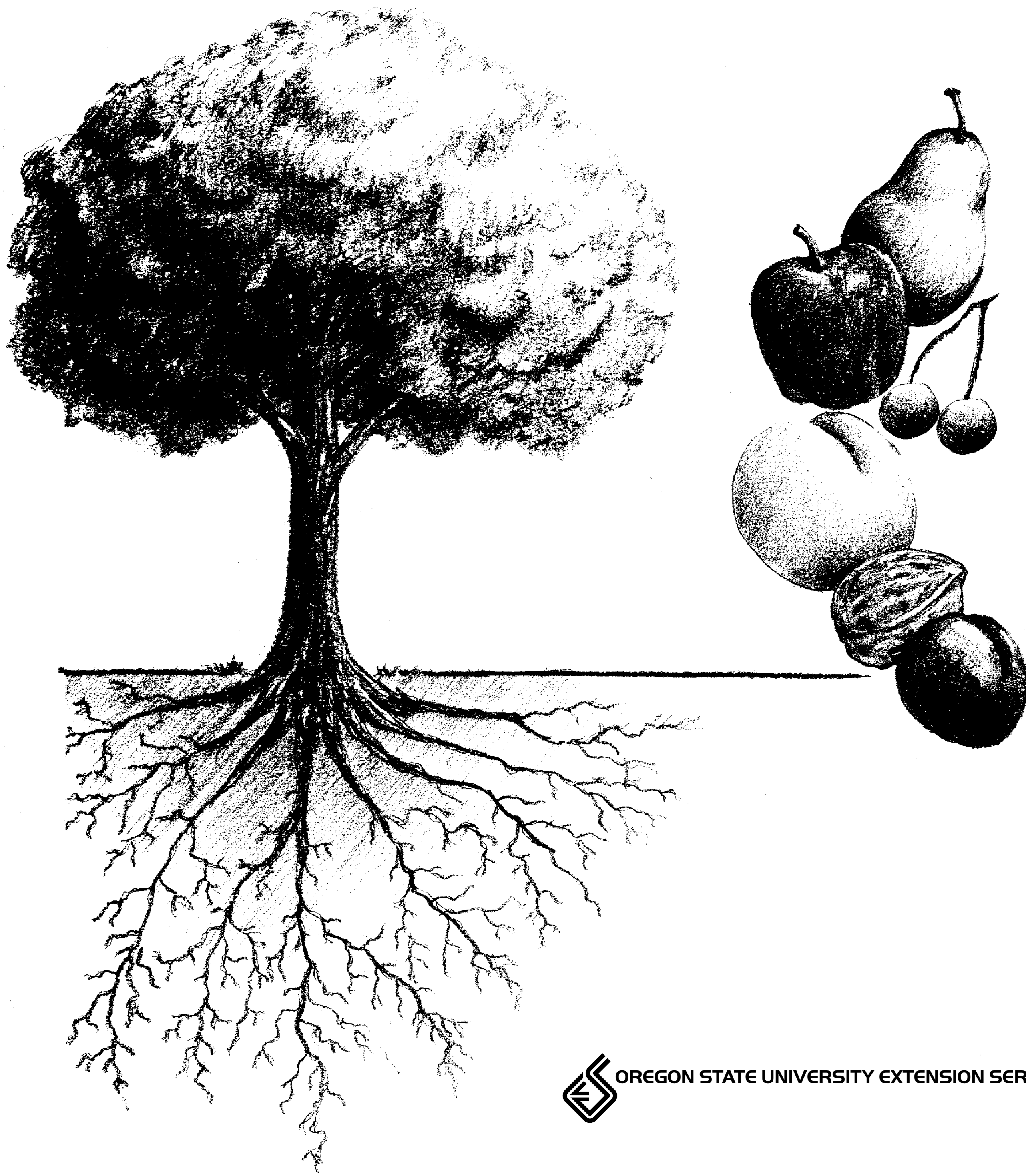

OREGON STATE UNIVERSITY EXTENSION SERVICE

Irrigating Deciduous Fruit and Nut Trees in Oregon

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Adequate soil moisture is one of the most important factors in tree growth and production. The amount of irrigation needed varies greatly according to soil type and depth, season, weather, and tree size.

This publication discusses these factors so you can better determine when and how much to irrigate. Modern moisture-measuring instruments, such as tensiometers and electrical resistance blocks, can help you make these decisions.

Soil moisture and tree growth

Picture your soil as a water reservoir or a sponge. When soil is at field capacity, the "sponge" contains all except the excess water, which was allowed to drain. Tree roots spread through this "sponge" or reservoir to pick up water and nutrients for food-making processes in the tree canopy, gradually depleting the water supply.

Roots of mature trees normally spread laterally at least 3 to 6 feet beyond the drip line. Roots of old seedling trees in deep soils can penetrate up to 6 feet in depth. Three or 4 feet is normal for 10- to 30-year-old trees. Dwarf trees with clonally propagated roots have shallower roots, perhaps penetrating up to 30 inches.

If a clay layer hardpan or rock substrata limits soil depth, the depth of the reservoir and the tree's roots will be restricted. In these circumstances, trees need water more often than trees growing in deeper soil, but they require only about half as much water at each irrigation.

In the dormant season, 20 to 40 inches of rainfall fully wets the soil around the roots of mature trees. This, however, is more than most soils will store. Most soils will store ¾ inch to 2½ inches of water per foot of soil depth. This water is available to plant roots. The excess water beyond storage capacity percolates below the root zone and is lost to the tree.

During the summer, sporadic showers usually don't penetrate as deeply. Therefore, irrigation is necessary for good tree and fruit or nut growth.

Irrigation usually is applied June through September. A full "soil reservoir," followed by periods of partial soil moisture, allows the soil aeration needed for healthy roots and keeps mature trees growing through harvest. You should base irrigation on soil moisture condition and tree needs during each period of the growing season. See Regulated Deficit Irrigation on page 7 for suggestions on how to save water and power.

For good tree growth, available water can be removed completely from the top foot of soil. Up to two-thirds can be used from lower depths in early to mid-season. Irrigation should replenish the full soil reservoir during fruit sizing in late season.

If the soil is drier than this, tree and fruit growth may decrease. If moisture demand by transpiration is

Table 1.—Average consumptive use and net irrigation requirement for orchards in the Willamette Valley in acre-inches.

			Actual irrigation required due to inefficiencies	
	Consumptive Use	**Irrigation Requirement**	**Furrow (50% loss)**	**Sprinkler (25% loss)**
April	0.81	—	—	—
May	3.33	1.28	2.56	1.71
June	4.56	3.19	6.38	4.25
July	5.32	4.97	9.94	6.63
Aug	4.39	3.91	7.82	5.21
Sept	2.07	0.52	1.04	0.69
Oct	0.54	—	—	—
Total	21.02	13.87	27.74	18.49

Source: OSU Agricultural Experiment Station Circular 628.

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greater than the roots can supply, water shortage in the tree will occur. Moisture then will be transferred from the fruit to satisfy the tree's demand. Fruit size decreases and, in extreme cases, the fruit may shrivel when dry trees are forced to pull water out of the fruit. Also, roots cannot pick up nutrients readily if the soil is too dry.

How much water do my trees use?

Trees vary in size and vigor, and the crop size varies from year to year. Also, temperatures and humidity vary during any one month and between years. Therefore, it is impossible to predict the exact amount of water your trees will need.

Consumptive use (CU) is the amount of water used by the trees in an average year. It does not take into account inefficiencies such as runoff, deep percolation, evaporation, etc. The *average orchard irrigation requirement* (IR) in the Willamette Valley is the amount of water that must be added to stored winter rain to meet consumptive use for each month during the growing season (Table 1).

When should I start irrigating?

Start irrigation *before* trees exhibit effects of water shortage. To avoid wasting water *or* under-irrigating, find out how much water has been drawn from the soil before you irrigate. For example, the top foot of soil may be dry by June 1 to June 15. Traditionally, start irrigating when approximately two-thirds of the 2-, 3-, and 4-foot moisture levels have been used. Regulated deficit irrigation (RDI), discussed on page 7, indicates how and why to delay and limit early irrigation.

Table 2 gives some guidelines for determining soil moisture level. More accurate readings can be achieved with tensiometers and moisture blocks (see page 4). Use soil augers to examine your soil at different depths and check your tensiometer or electrical resistance block readings. Check the soil in several places in the orchard to determine where to irrigate first.

Record tensiometer or moisture block readings before irrigation, 2 days after irrigation, and several

Table 2.—Soil moisture characteristics.

Water available to plants	Soil moisture level	Textural appearance		
		Coarse (loamy sand, sandy loam)	**Medium** (fine sandy loam, silt loam)	**Fine** (clay loam, clay)
All gone!	No available soil moisture. Plants wilt. Irrigation water already should have been applied.	Dry, loose clods are easily crushed and will flow through fingers. No stain or smear on finger.	Crumbly, dry, powdery. Clods break down easily into a powdery condition. May leave slight smear or stain when worked with hands or fingers.	Hard, firm baked, cracked. Usually too stiff or tough to work or ribbon.*
Two-thirds gone	Moisture is available, but level is low. Irrigation is required.	Appears dry; may tend to make a cast,** but seldom will hold together.	May form a weak cast or ball** under pressure, but still will be crumbly. Color is pale, with no obvious moisture.	Pliable, forms a cast or ball.** Will ribbon,* but usually breaks or is crumbly. May leave slight smear or stain.
One-half gone	Moisture is available. Level is high. Irrigation not required, but watch closely.	Color is darkened with obvious moisture. Soil forms a weak ball or cast** under pressure. It makes a slight finger stain, but no ribbon.*	Color is darkened from obvious moisture. Forms a ball or cast.** Works easily, clods are soft with mellow feel. Will stain finger and have slick feel when squeezed.	Color is darkened with obvious moisture. Forms good ball or cast.** Ribbons* easily, has slick feel. Leaves stain or smear on fingers.
Soil is full	Soil moisture level following an irrigation. Check moisture at lower root depths.	Appears and feels moist. Color is darkened. Forms cast or ball.** Will not ribbon,* but will show smear or stain and leave wet outline on hand.	Appears and feels moist. Color is darkened; has a smooth, mellow feel. Forms ball,** and will ribbon* when squeezed. Stains and smears; leaves wet outline on hand.	Color is darkened. Appears moist, may feel sticky. Ribbons* easily, smears and stains hand. Leaves wet outline. Forms good cast or ball.**

*Ribbon is formed by squeezing and working soil between thumb and forefinger.
**Cast or ball is formed by squeezing soil in hand.

times between irrigations. This enables you to develop an excellent record of soil moisture trends, which will help you plan future irrigation frequency. The recordings plus soil samples (see Table 2) help determine the amount of moisture remaining in the soil over a large area of the orchard. Evaporation pans also have been used successfully to determine irrigation frequency.

Tensiometers

A tensiometer is a closed, water-filled tube with a vacuum gauge on top and a porous tip at the bottom through which water seeps (Figure 1). The gauge indicates the amount of suction required to draw water from the soil. Suction increases as the soil becomes dry and decreases as water is added to the soil.

Tensiometer gauge readings are an index to soil moisture and do not require further interpretation for individual soils. Tree roots must exert the same energy to draw water from the soil as is indicated on the tensiometer gauge.

Install tensiometers on the southwest side of trees in representative areas of the orchard. At each site, install two instruments, one at one-third and the other at two-thirds the active root depth (Figure 2.) Use two stations in a 5- to 10-acre orchard and proportionally more in larger orchards.

Sandy soils should be irrigated sooner than clay-type soils because sandy soils hold less water.

In coarse-textured soils (sandy), start irrigating when tensiometer readings at either depth reach 40 to 50. In medium- to fine-textured soils (clayey), irrigate when the tensiometer gauges read 60 to 70.

Moisture blocks

Moisture blocks also show soil moisture. Moisture blocks consist of gypsum or fiberglass blocks with electrical leads that are buried at two depths in a tree's root zone (Figure 3). Resistance to electrical flow is measured with a portable meter. Dry blocks in dry soil have greater resistance to electrical flow than wet blocks in wet soil. The meters come with charts that show relative dryness in various types of soil and will help you determine when to irrigate. The Watermark construction measures moisture lower than the gypsum type and higher than tensiometers.

How much water should I apply?

Your irrigation requirement partly depends on how much water your soil can store for future use. Therefore, the first step in calculating your irrigation needs is to determine how much water 1 cubic foot of your soil will hold.

Clay and loam soils have greater water-holding capacity than do sandy soils because they have more pores, which retain more water (Table 3). Most pores in clay loam or fine-textured soils are medium to small in size and can retain considerable water in the numerous pores due to strong surface tension. Most pores in coarse-textured sandy soils are large in size, but there are fewer of them and they retain little water.

Once the root area is completely wet, it will not hold more water. Additional water percolates below the root zone and is wasted. Fertilizer may leach below the roots and contaminate groundwater. Calcium also is leached, resulting in soil acidification and poor nutrient uptake. In addition, too much water can cause root rot.

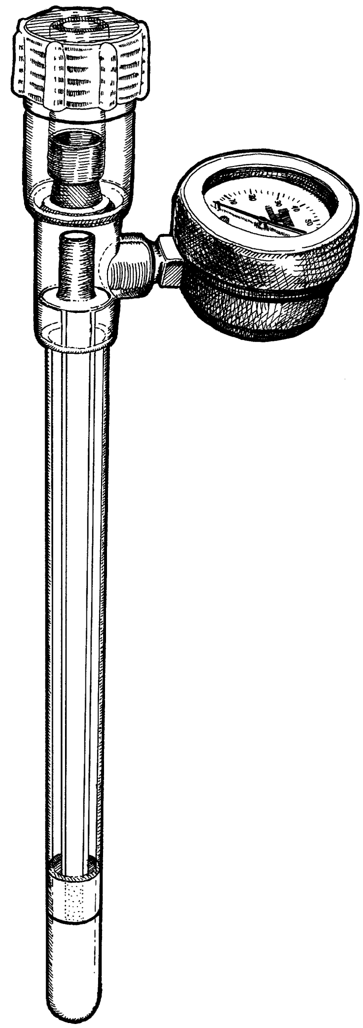

Figure 1.—Tensiometer.

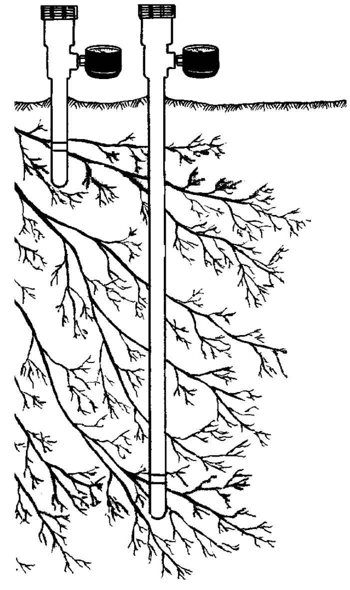

Figure 2.—Tensiometer placement.

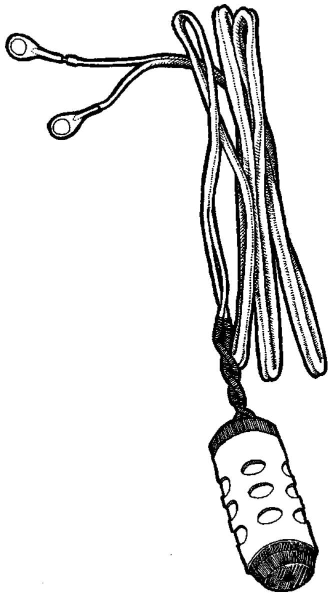

Figure 3.—Moisture block.

A dense clay layer, or hardpan, just below the root system keeps excess water from draining. This results in a perched water table, which causes “wet feet” or root injury. Careful water management or preplant deep soil ripping is needed to control these conditions.

Example

Assume your sandy loam soil is 4 feet deep with good drainage and a water-holding capacity of 1½ inches of water per foot of depth. The total amount of water your soil can hold in 4 feet is 6 inches.

Also assume that the top foot of soil is dry and two-thirds of the moisture in the 2-, 3-, and 4-foot levels has been used. This means that only $^1/_2$ inch of water remains in each of these levels, so each one needs 1 inch of water to be filled to capacity. So, you need:

Water to fill the first foot	1.5"
1 inch of water for each of the 2-, 3-, and 4-foot levels	3.0"
Total water needed to refill the soil	4.5"

When you irrigate, water is lost through evaporation, runoff, and extra-deep penetration at row tops and in sandy spots. Extra water is needed to offset these inefficiencies. Average irrigation efficiency is 50 percent in furrows and 75 percent with sprinklers (see Table 1). Therefore, the total water needed in the example is:

Furrows:
4.5 inches x 2 = 9 inches

Sprinklers:
4.5 inches x 1.3 = 6 inches

Table 3.—Water-holding capacity of soils.

Soil type	Available water per foot of depth
Sandy	1.5–1"
Fine sand, sandy loam	1–1.5"
Heavy loam, clay loam	1.5–2.5"

How long should I irrigate?

Once you have determined how much water is needed to refill the soil, you need to figure out how long to run your system to apply that much water. To do so, you first must find your system’s water flow rate in acre-inches.

Water delivery normally is measured by flow measurements such as gallons per minute, sprinkler discharge per head, or cubic feet per second. These measurements describe a quantity of water delivered in a certain period of time. They should be converted to acre-inches (the volume of water required to cover 1 acre of soil 1 inch deep) in order to compare the amount of water applied to the amount required in a given period. For example, applying 450 gallons per minute (gpm) for 1 hour supplies 1 acre-inch of water.

The box below shows how to convert water flow into acre-inches per hour.

Converting water flow rates to acre-inches per hour

If water is delivered in *gallons per minute* (gpm):

$$\frac{\text{your gpm}}{450} = \text{acre-inches per hour}$$

Example: $\frac{900 \text{ gpm}}{450} = 2$ acre-inches per hour

If water is delivered in *cubic feet per second* (cfs):

your cfs = acre-inches per hour

Example: 2 cfs = 2 acre-inches per hour

If you know the *gallons per minute per sprinkler head*:

$$\frac{\text{gpm per sprinkler x 96.3 (constant)}}{\text{area covered (sprinkler spacing)}} = \text{inches per hour}$$

Example: $\frac{2 \text{ gpm x } 96.3}{20 \text{ x } 25 \text{ ft}} = \frac{192.6}{500} = 0.385$ inch per hour

(This rate, applied for 12 hours, equals 4.62 rainfall inches on the area covered.)

Once you know your flow rate in acre-inches per hour and how much water you need to apply, you can calculate how long to run your irrigation system as follows:

$$\frac{\text{acre-inches needed}}{\text{acre-inches per hour}} = \text{hours to irrigate}$$

Example 1

Continuing with the example above, assume you are using sprinklers, so you need to apply 6 inches of water per acre. Next, determine the volume of water pumped or the amount the water district delivers in one hour. Then convert this amount to acre-inches per hour (see page 5). For example, if your water flow is 225 gpm, you find that this is ½ acre-inch per hour.

Finally, determine the number of hours of irrigation required to apply 6 inches per acre:

$$\frac{\text{6 inches}}{\text{½ acre-inch per hour}} = \text{12 hours}$$

You must irrigate each acre for 12 hours to bring the soil moisture content to field capacity.

Example 2

You could estimate your monthly irrigation need the same way by using Table 1. For example, 6.63 acre-inches are required for July if you are using a sprinkler system. Therefore, if you calculated your sprinkler discharge per head as 0.385 inch per hour (above), you would figure the number of hours to irrigate as follows:

$$\frac{6.63}{0.385} = 17.2 \text{ hours}$$

If you apply this amount in four weekly irrigations, you need to irrigate for 4.3 hours each time (17.2 ÷ 4 = 4.3). Or, if you irrigate once every other week, you need to irrigate for 8.6 hours each time (17.2 ÷ 2 = 8.6).

Frost protection

Overhead irrigation for frost protection was developed at the Oregon State University Southern Oregon Experiment Station in Medford in the 1960s and now is used on apples, pears, and grapes in many parts of the world. The heat of fusion, liberated from freezing water, helps protect the buds and bloom from spring frosts.

If you wish to use overhead sprinklers for spring frost protection, consult an irrigation engineer or county Extension agent. Adequate flow must be designed into the system for frost protection. There must be a reliable water supply at 65 gallons per acre per minute for up to 8 or 10 hours on 2 to 3 consecutive nights. Sprinkler design should include a uniform application over the orchard. See Table 4 for application rates.

Use frost protection sprinklers that rotate at 30 to 60 seconds. Turn the system on at 1° to 2°F above critical temperature at bloom stage. Turn it off in the morning when ice is melting or the temperature is above 32°F.

Precautions

- Young trees can withstand less ice before their limbs break than old trees can.
- If power, water supply, or sprinklers fail, trees will sustain more damage than if they were dry.
- Diseases such as blight and scab of apples and pears may increase unless you take extra precautions to control them.
- Increase of many diseases including pseudomonas, brown rot, and coryneum make overhead frost protection impractical for stone fruits.

Table 4.—Application rates needed to hold bud temperature to 31°F.

Rate per hour	Outside temperature
0.17"	24°F
0.15"	25°F
0.13"	26°F

- Excessively wet soils can induce root rot and asphyxiation.
- Poor pollination may result from pollen washing off the flowers.

Drip irrigation

A drip irrigation system requires good filtration to prevent emitter plugging. Flow rates generally vary from ½ gph for slow infiltration to 4 or 5 gph for fast penetration. Small flow emitters have more plugging problems, but low application rates provide better lateral water flow in the soil.

Install lines in new orchards with about 4 feet of slack near the lateral pipe. As trees grow larger, they demand more water over a larger root area. After 3 or 4 years, pull the loop that places the point of application out to about 3 or 4 feet from the trunk. Then add a second emitter 3 or 4 feet away (Figure 4). You can add additional emitters or microtubes as needed.

Amount and frequency

Newly planted trees require 5 to 8 gallons of water per week in summer, usually split between two applications, especially on sandy soils. The amount depends on heat, wind, and the soil's water-holding capacity.

Drip irrigation should begin in each growing season while good, but not excessive, soil moisture exists. If you wait until soils are

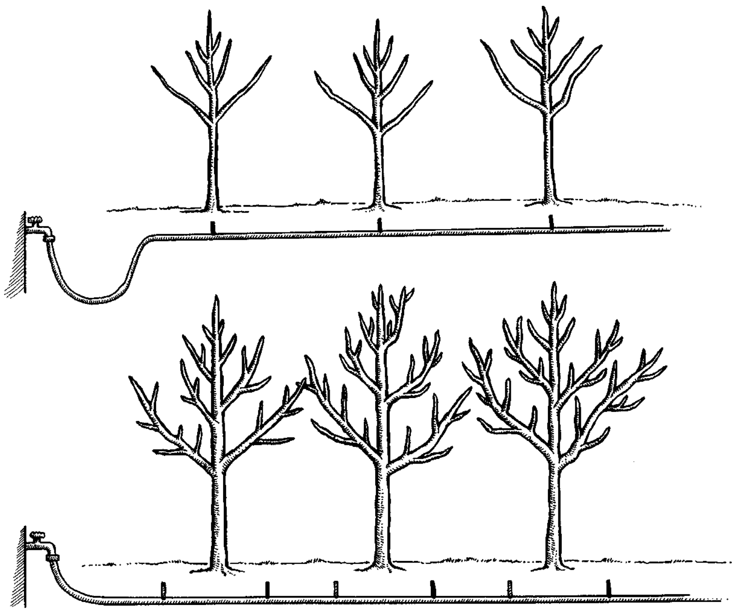

Figure 4.—Drip irrigation placement.

excessively dry, drip irrigation will penetrate vertically but have little horizontal spread. More roots are satisfied with maximum lateral spread of moisture.

Each year, increase the amount of weekly irrigation about 50 percent. Sample the soil with an auger or use tensiometers placed at the edge of the wet zone (approximately 18 inches from the emitter on the south or west side of the tree) to monitor soil moisture, pattern, and root health. Adjust rates and frequency accordingly.

Irrigation volume is changed principally by size or number of emitters, frequency of application, and hours per application. The least change is by pressure, which is specified by the manufacturer.

Mature trees, depending on vigor and planting density, may use 24 to 50 gallons of water per week or about 26 acre-inches per season.

Drip emitters are coded or marked, but you can check them by collecting water from one emitter into a metric measure for 1 minute. One milliliter per second is approximately 1 gallon per hour (gph).

Example:

60 ml in 60 seconds = 1 gph flow

or

60 ml in 30 seconds = 2 gph flow

Regulated deficit irrigation

Regulated deficit irrigation (RDI) is a concept developed at the Tatura Experiment Station, Victoria, Australia. It is simple, saves water and power (in early season), and saves some shoot growth and pruning at no expense to fruit growth.

To use RDI, eliminate irrigation in the early stages (Stages 1 and 2 in Figure 5). Water deficit and minor stress will minimize vegetative growth with little or no adverse effect on fruit growth.

Adequate irrigation during rapid fruit growth in Stage 3 satisfies the tree and fruit growth requirements. Stage 3 generally would be the last 6 to 7 weeks before harvest in apples and pears, 5 weeks prior to harvest for stone fruit (4 weeks for cherries), and 5 weeks for nut crops.

RDI is being practiced successfully by many producers in the Australian fruit industry.

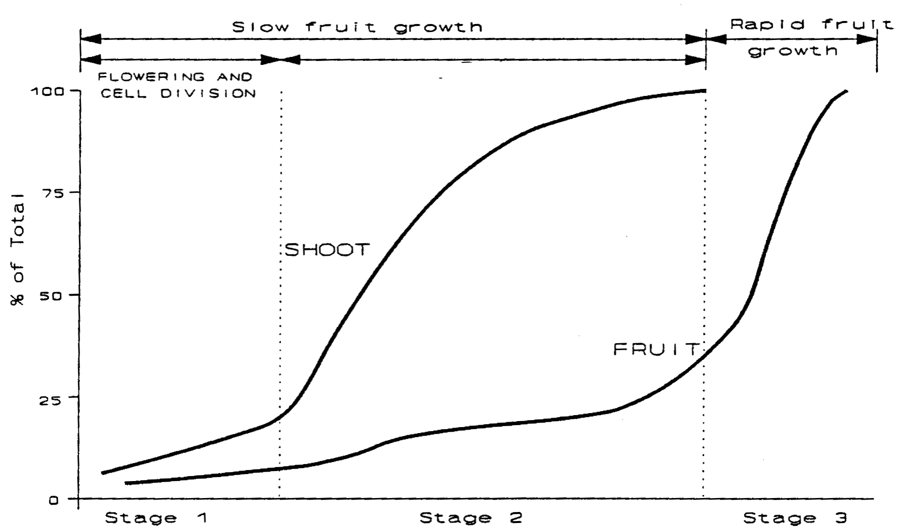

Figure 5.—Regulated deficit irrigation.

Worksheet

Step 1. First, gather the following information, which you'll need to figure out how much to irrigate:

Soil type______________________

Soil depth____________

Water-holding capacity per foot:____________

sandy soil = ½"–1"

sandy loam = 1"–1½"

clay loam = 1½"–2½"

Percentage of moisture used in top foot (from moisture block or tensiometer)_________

Percentage of moisture used in soil below the top foot (from moisture block or tensiometer)______

Flow rate of irrigation system in cfs or gpm _________________

If sprinkler, area covered by one sprinkler (square feet)______________________

Step 2. Calculate the water needed to refill the soil.

Top foot:

_____________ x __________ → [ ]

percent moisture used* capacity/foot

Soil below the top foot:

_____________ x ________ x _________ → + [ ]

percent moisture used* capacity /foot soil depth minus top foot

*Example: If you've used 100% of the water, enter 1; if you've used 60% of the water, enter .60

[ ] Water needed (acre-inches)

Step 3. Calculate the irrigation needed, taking into account inefficiencies in your system.

If furrow __________ x 2

water needed

If sprinkler _________ x 1.3

water needed

→ [ ] Irrigation needed (acre-inches)

Step 4. Calculate your flow rate in acre-inches per hour.

If cfs ______________

flow rate in cfs

If gpm ______________ ÷ 450

flow rate in gpm

If sprinkler discharge per head

_______________ x 96.3 ÷ _______________

gpm per sprinkler area covered by 1 sprinkler

→ [ ] Flow rate (acre-inches per hour)

Step 5. Calculate how long to irrigate

______________ ÷ ______________ → [ ] Hours to irrigate

irrigation needed flow rate (acre-inches per hour)